US009176599B2

(12) **United States Patent**
Ichieda

(10) **Patent No.: US 9,176,599 B2**
(45) **Date of Patent: Nov. 3, 2015**

(54) **DISPLAY DEVICE, DISPLAY SYSTEM, AND DATA SUPPLY METHOD FOR DISPLAY DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 295 days.

(21) Appl. No.: **13/710,703**

(22) Filed: **Dec. 11, 2012**

(65) **Prior Publication Data**

US 2013/0162538 A1 Jun. 27, 2013

(30) **Foreign Application Priority Data**

Dec. 27, 2011 (JP) 2011-285318

(51) **Int. Cl.**
G09G 5/00 (2006.01)
G06F 3/033 (2013.01)
G06F 3/041 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/033*** (2013.01); ***G06F 3/0416*** (2013.01); ***G09G 5/00*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/033; G06F 3/0416; G06F 3/0488
USPC 345/156–173
See application file for complete search history.

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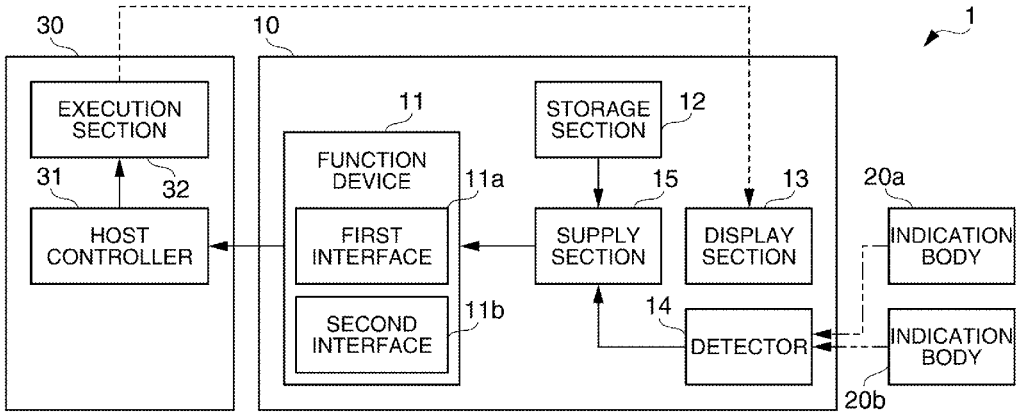
(57) **ABSTRACT**

A display device can make it possible to easily recognize a plurality of indication bodies as a plurality of pointing devices. The display device is provided with a function device having a first interface and a second interface, and stores configuration information assigning the same class to the first interface and the second interface in a storage section. The display device detects a first position indicated by a first indication body to a display surface and a second position indicated by a second indication body to the display surface, assigns first coordinate data representing the first position to the first interface, assigns second coordinate data representing the second position to the second interface, and supplies a host device with the first coordinate data and the second coordinate data.

20 Claims, 7 Drawing Sheets



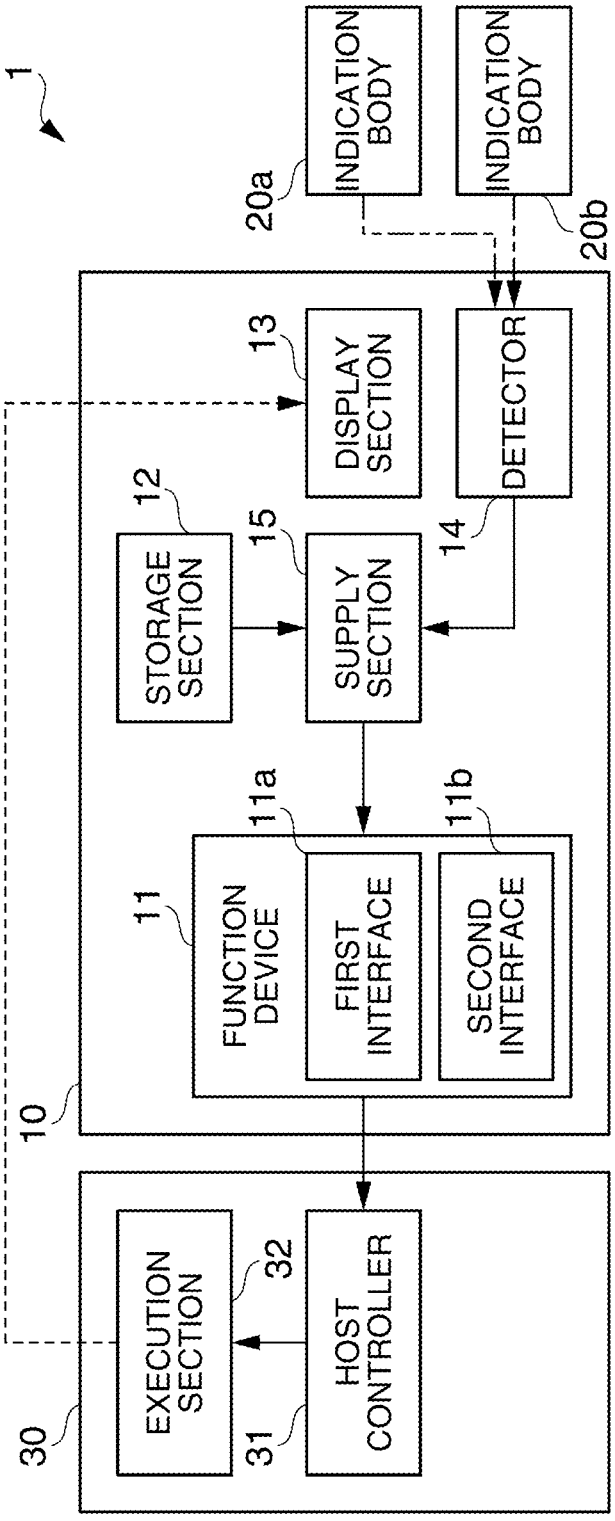

1
INDICATION BODY
INDICATION BODY
20a
20b
DISPLAY SECTION
13
DETECTOR
STORAGE SECTION
12
15
SUPPLY SECTION
14
11a
11b
11
FUNCTION DEVICE
FIRST INTERFACE
SECOND INTERFACE
10
EXECUTION SECTION
32
HOST CONTROLLER
30
31

FIG. 1

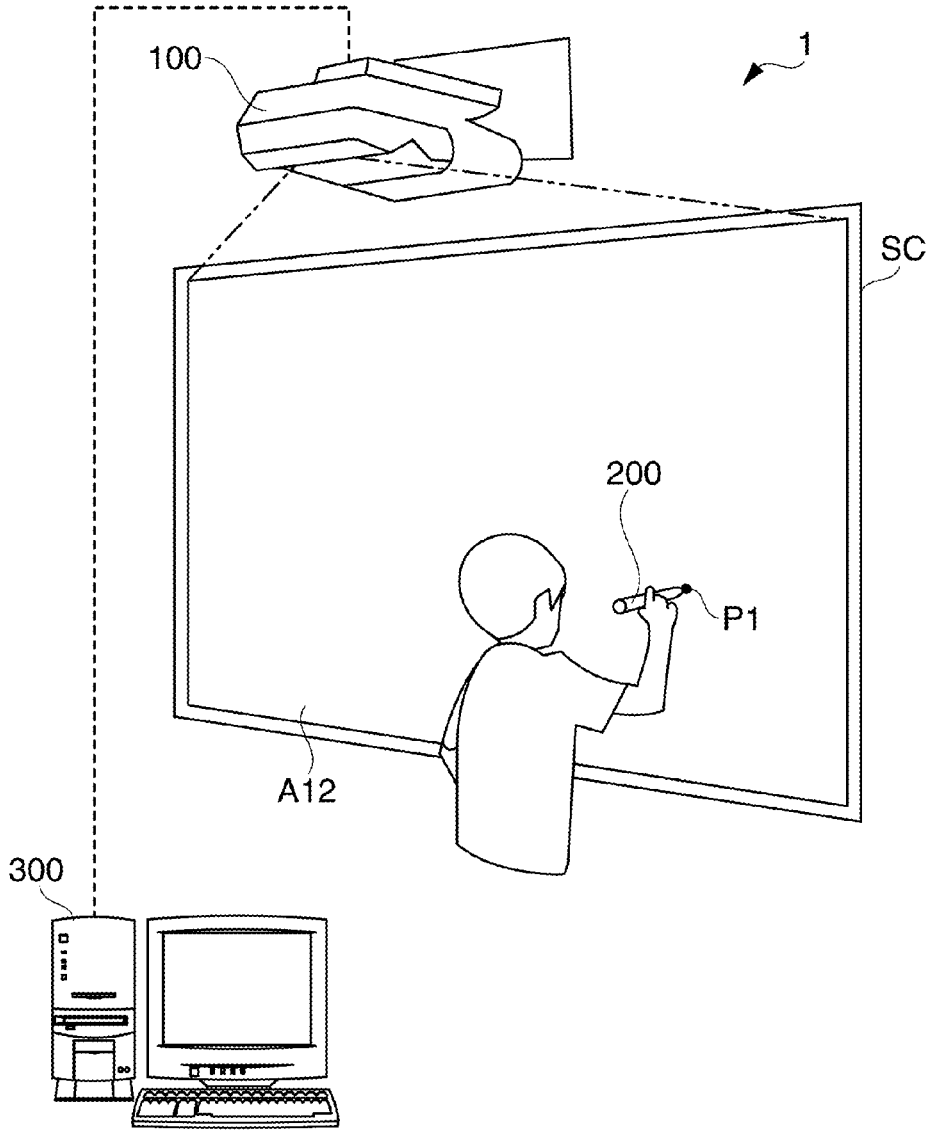


FIG. 2

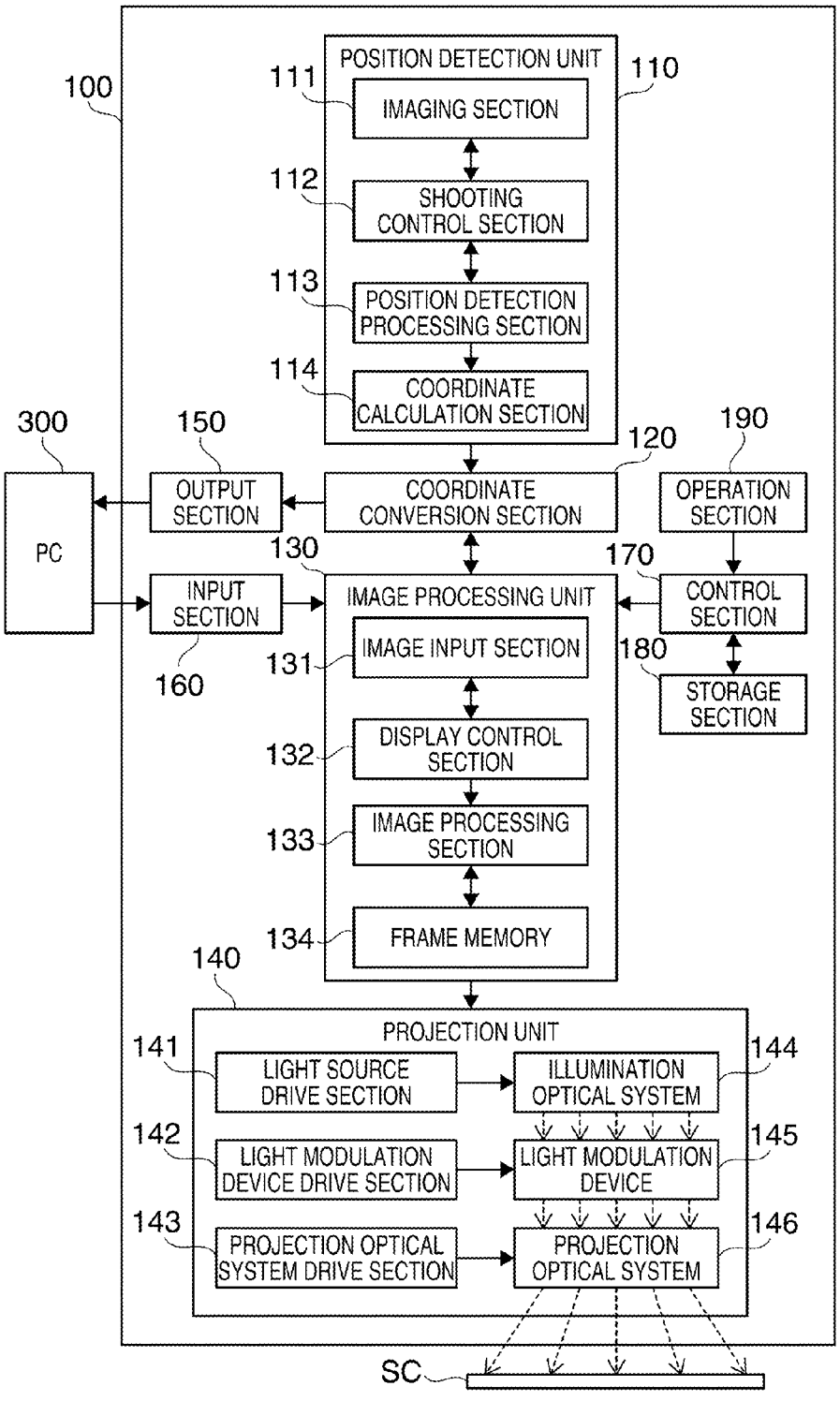

100
POSITION DETECTION UNIT
110
111
IMAGING SECTION
112
SHOOTING CONTROL SECTION
113
POSITION DETECTION PROCESSING SECTION
114
COORDINATE CALCULATION SECTION
300
150
120
190
PC
OUTPUT SECTION
COORDINATE CONVERSION SECTION
OPERATION SECTION
130
170
INPUT SECTION
IMAGE PROCESSING UNIT
CONTROL SECTION
160
131
IMAGE INPUT SECTION
180
STORAGE SECTION
132
DISPLAY CONTROL SECTION
133
IMAGE PROCESSING SECTION
134
FRAME MEMORY
140
PROJECTION UNIT
141
144
LIGHT SOURCE DRIVE SECTION
ILLUMINATION OPTICAL SYSTEM
142
145
LIGHT MODULATION DEVICE DRIVE SECTION
LIGHT MODULATION DEVICE
143
146
PROJECTION OPTICAL SYSTEM DRIVE SECTION
PROJECTION OPTICAL SYSTEM
SC

FIG. 3

FIG. 4

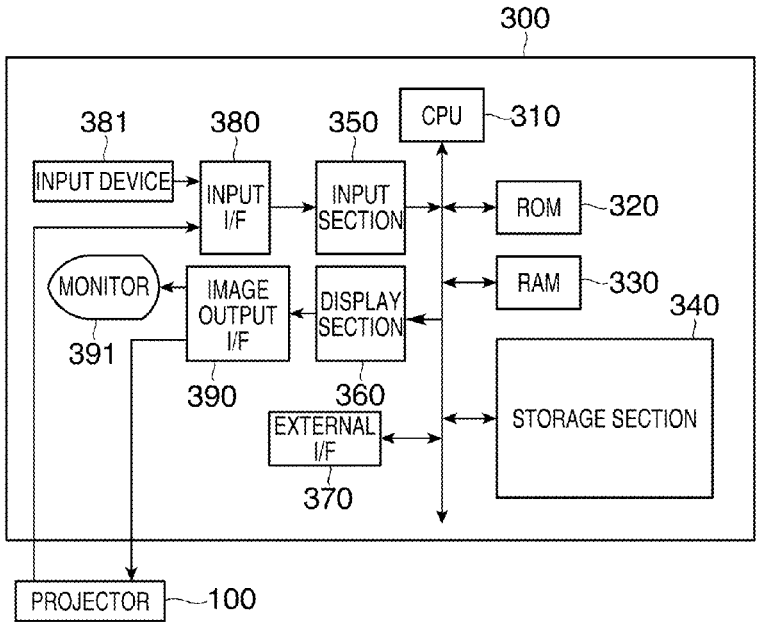


FIG. 5

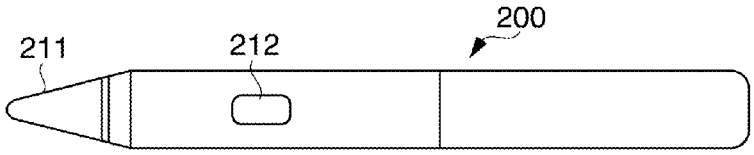
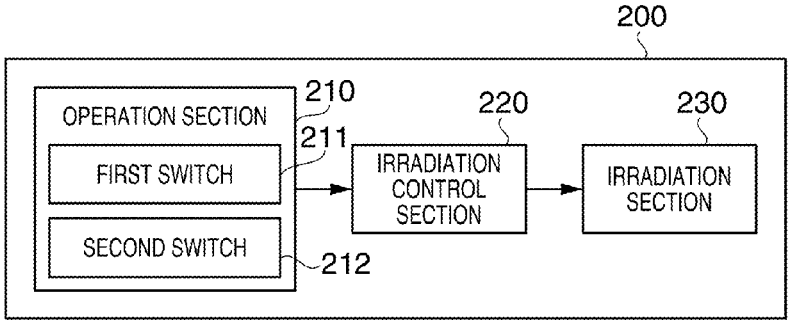


FIG. 6



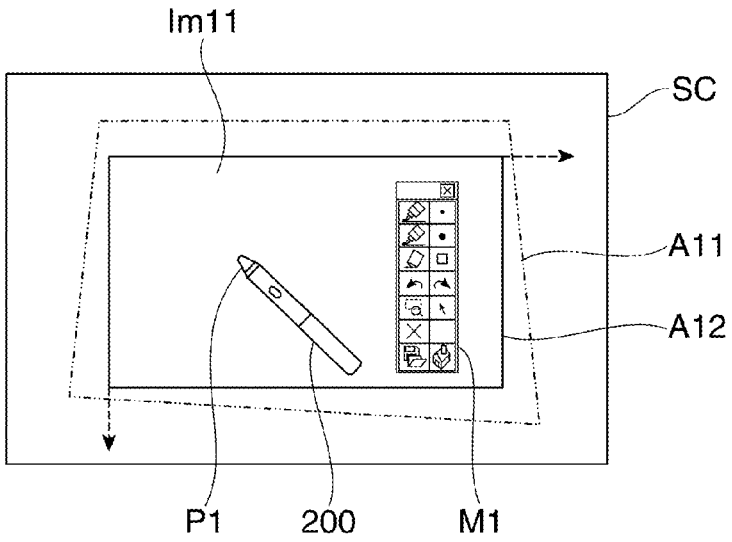


FIG. 7A

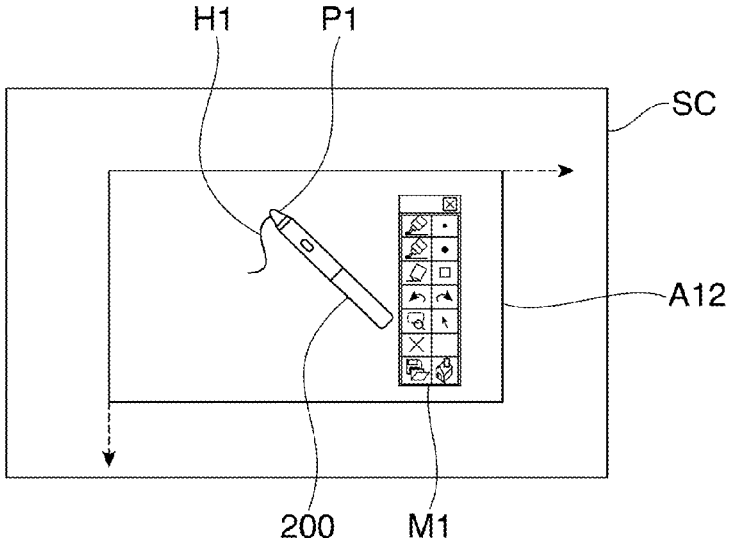


FIG. 7B

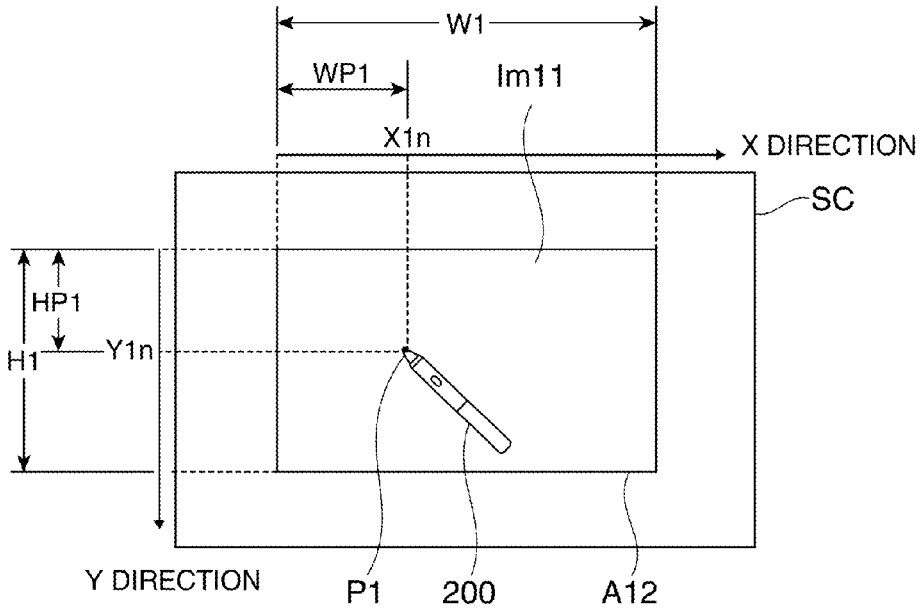

W1
WP1
Im11
X1n
X DIRECTION
SC
HP1
H1
Y1n
Y DIRECTION
P1
200
A12

FIG. 8A

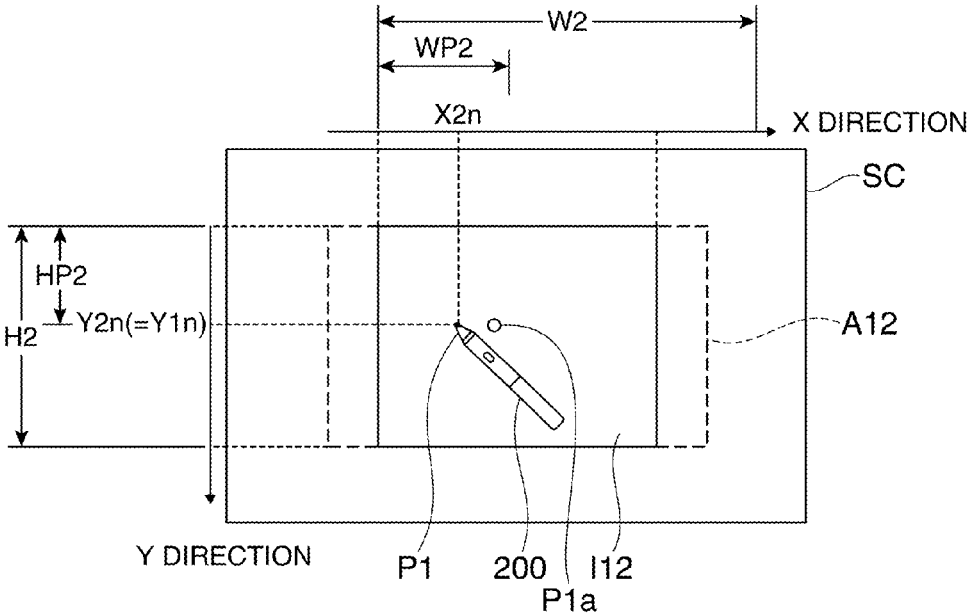

W2
WP2
X2n
X DIRECTION
SC
HP2
H2
Y2n(=Y1n)
A12
Y DIRECTION
P1
200
P1a
I12

FIG. 8B

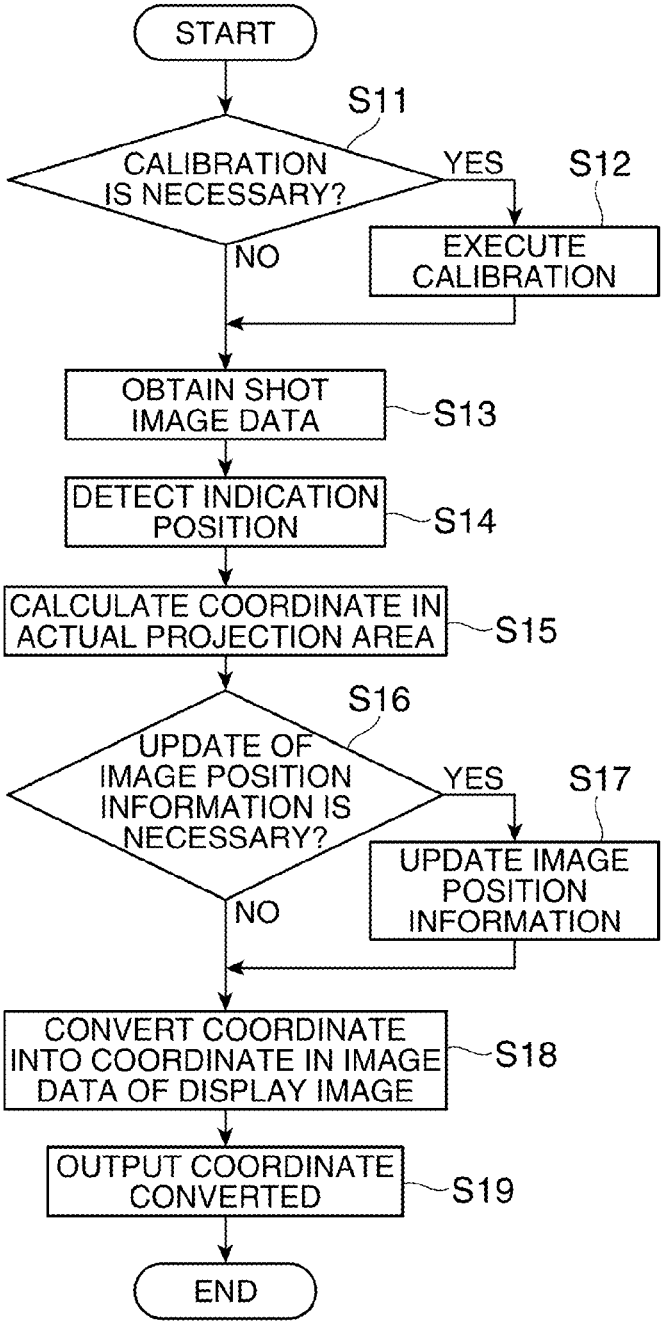

START
S11
CALIBRATION IS NECESSARY?
YES
S12
EXECUTE CALIBRATION
NO
OBTAIN SHOT IMAGE DATA
S13
DETECT INDICATION POSITION
S14
CALCULATE COORDINATE IN ACTUAL PROJECTION AREA
S15
S16
UPDATE OF IMAGE POSITION INFORMATION IS NECESSARY?
YES
S17
UPDATE IMAGE POSITION INFORMATION
NO
CONVERT COORDINATE INTO COORDINATE IN IMAGE DATA OF DISPLAY IMAGE
S18
OUTPUT COORDINATE CONVERTED
S19
END

FIG. 9

DISPLAY DEVICE, DISPLAY SYSTEM, AND DATA SUPPLY METHOD FOR DISPLAY DEVICE

BACKGROUND

1. Technical Field

The present invention relates to a technology for recognizing an operation to a display surface.

2. Related Art

In the past, there has been known a device, which, when a specific position of an image displayed by a display device such as a projector is indicated with a pointing device, detects an indication position, and then displays a pointer or the like so as to correspond to the position thus detected (see, e.g., Japanese Patent No. 4272904 (Document 1)). By drawing the trajectory of the position detected using the device described in Document 1, it is possible to display characters, figures, and so on written by hand.

Incidentally, although it is often the case that the USB (Universal Serial Bus) is used for connecting between devices, in the case in which it is attempted to recognize the indication positions of a plurality of pointing devices in a host device, it is required to connect between the devices with a plurality of ports and cables, or to install a dedicated device driver.

SUMMARY

An advantage of some aspects of the invention is to make it possible to easily recognize a plurality of indication bodies as a plurality of pointing devices.

A display device according to an aspect of the invention is configured to include a function device connected to a host device in a manner compliant with a USB (Universal Serial Bus) standard, and having a first interface and a second interface, a storage section storing configuration information, which assigns the same class to the first interface and the second interface, a display section adapted to display an image on a display surface, a detector adapted to detect a first position indicated by a first indication body and a second position indicated by a second indication body to the display surface, and a supply section adapted to assign first coordinate data representing the first position detected by the detector and supply the host device with the first coordinate data via the function device, and assign second coordinate data representing the second position detected by the detector and supply the host device with the second coordinate data via the function device.

In a preferable aspect of the invention, the supply section supplies the host device with the configuration information stored in the storage section prior to supplying the host device with the first coordinate data and the second coordinate data.

In another preferable aspect of the invention, the display section displays the image on the display surface by projecting light.

A display device according to another aspect of the invention is configured to include a function device connected to a host device in a manner compliant with a USB standard, and having a first interface and a second interface, a storage section storing configuration information, which assigns the same class to the first interface and the second interface, a display section adapted to display an image on a display surface, a detector adapted to detect a first position indicated by a first indication body and a second position indicated by a second indication body to the display surface, and a supply section adapted to supply the host device with the configuration information stored in the storage section, first coordinate data representing the first position detected by the detector, and second coordinate data representing the second position detected by the detector via the function device, and further to assign the first coordinate data to the first interface, and the second coordinate data to the second interface, and supply the first coordinate data and the second coordinate data.

According to the display device of this aspect of the invention, it is possible to make it possible to easily recognize a plurality of indication bodies as a plurality of pointing devices.

In a preferable aspect of the invention, the storage section stores the configuration information, which assigns HID (Human Interface Device) class to the first interface and the second interface.

According to this preferable aspect of the invention, it is possible to recognize a plurality of indication bodies without installing the dedicated device driver on the host device.

In another preferable aspect of the invention, the storage section stores the configuration information, which assigns a sub-class corresponding to a mouse to the first interface, and assigns a sub-class corresponding to a digitizer to the second interface.

According to this preferable aspect of the invention, a plurality of indication bodies can be recognized as the pointing devices different from each other.

Alternatively, the storage section may store the configuration information assigning the sub-class corresponding to a mouse to the first interface and the second interface, or may store the configuration information assigning the sub-class corresponding to a digitizer to the first interface and the second interface.

A projector according to still another aspect of the invention is configured to include a function device connected to a host device in a manner compliant with a USB standard, and having a first interface and a second interface, a storage section storing configuration information, which assigns the same class to the first interface and the second interface, a display section adapted to display an image on a display surface by projecting light, a detector adapted to detect a first position indicated by a first indication body and a second position indicated by a second indication body to the display surface, and a supply section adapted to supply the host device with the configuration information stored in the storage section, first coordinate data representing the first position detected by the detector, and second coordinate data representing the second position detected by the detector via the function device, and further to assign the first coordinate data to the first interface, and the second coordinate data to the second interface, and supply the first coordinate data and the second coordinate data.

According to the projector of this aspect of the invention, it is possible to make it possible to easily recognize a plurality of indication bodies as a plurality of pointing devices.

A display system according to yet another aspect of the invention is configured to include the display device, the first indication body, the second indication body, and a host device having an execution section adapted to execute a process corresponding to one of the first position and the second position based on the configuration information, the first coordinate data, and the second coordinate data supplied via the function device.

According to the display system of this aspect of the invention, it is possible to make it possible to easily recognize a plurality of indication bodies as a plurality of pointing devices.

In a preferable aspect of the invention, the execution section executes a process of making the display section draw an image corresponding to one of the first position and the second position.

According to this preferable aspect of the invention, it is possible to reflect the indication by the indication body on the display by the display device.

The invention can be put into practice in various forms other than a device. The invention can be implemented in the forms of, for example, a data supply method, a computer program for realizing the method, and a non-temporary recording medium on which the computer program is recorded.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

FIG. **1** is a block diagram showing a functional configuration of a display system.

FIG. **2** is a diagram showing a configuration of the display system.

FIG. **3** is a block diagram showing a configuration of a projector.

FIG. **4** is a block diagram showing a configuration of a PC.

FIG. **5** is a diagram showing an example of an appearance of a pen.

FIG. **6** is a block diagram showing a configuration of the pen.

FIGS. **7**A and **7**B are diagrams exemplifying images displayed by the projector.

FIGS. **8**A and **8**B are explanatory diagrams showing the procedure of the process of detecting and converting the coordinate.

FIG. **9** is a flowchart showing an operation of the projector.

DESCRIPTION OF AN EXEMPLARY EMBODIMENT

One feature of the invention resides in receiving indication by a plurality of indication bodies in an identifiable manner in a display system capable of performing the process corresponding to the indication on the display surface made by the user using the indication body. The display system according to the invention has a configuration provided with a display device for displaying a plurality of indication bodies and an image, and detecting the positions indicated by the indication bodies, and a host device for performing the process corresponding to the indication by the indication bodies, wherein it is assumed that the host device and the display device are connected to each other in a manner compliant with the USB standard. The display system according to the invention is characterized in the point that the host device and the display device are connected to each other with a single USB cable.

It should be noted that in the invention, use of a plurality of indication bodies by a single user is not excluded. However, for the sake of convenience of explanation, it is assumed hereinafter that a single user uses one indication body, and further, the number of users performing indication to the display surface is two. In other words, a display system in which two users use one indication body for each, totally two indication bodies will hereinafter be explained.

FIG. **1** is a block diagram showing a functional configuration of a display system **1** according to an embodiment of the invention. The display system is provided at least with a display device **10**, indication bodies **20***a*, **20***b*, and a host device **30**. The display device **10** can be a device provided with the constituents shown in FIG. **1** integrally (i.e., in a single device), or a device realizing the constituents by cooperative operations of a plurality of devices.

The display device **10** is provided with a function device **11**, a storage section **12**, a display section **13**, a detector **14**, and a supply section **15**. Further, the host device **30** is provided with a host controller **31**, and an execution section **32**. The host controller **31** and the function device **11** are connected to each other via, for example, a USB cable, but can also be connected in a wireless manner via wireless USB or the like.

The function device **11** is a device for connecting the display device **10** to the host device **30**. The function device **11** is configured so as to be compliant with the USB standard, and has a first interface **11***a* and a second interface **11***b*. The first interface **11***a* and the second interface **11***b* are each configured including one or more endpoints. In other words, the function device **11** is a so-called composite device.

The storage section **12** is a device for storing configuration information. Here, the configuration information denotes the data (descriptor) for defining the configuration of the function device **11**. The configuration information of the embodiment of the invention is characterized in the point that the same class is assigned to the first interface **11***a* and the second interface **11***b*. The class assigned to the first interface **11***a* and the second interface **11***b* is preferably the human interface device (HID) class, which is a general-purpose class, but can be a unique class defined by a vendor or the like. Further, the configuration information of the embodiment of the invention includes the information representing the subclass (e.g., a mouse and a digitizer) besides the information representing the class.

The display section **13** is a device for displaying the image on the display surface. The display section **13** can be a device such as a liquid crystal display or an organic electroluminescence (EL) display provided with the display surface itself, or can be a device such as a projector using a screen, a wall surface, and so on as the display surface, and displaying an image by projecting light on the display surface.

The detector **14** is a device for detecting the position at which the user has performed indication to the display surface with the indication bodies **20***a*, **20***b*. The detector **14** optically detects or magnetically detects the indication by the indication bodies **20***a*, **20***b*, but the detection method itself is not particularly limited. The detector **14** outputs coordinate data representing the position thus detected. It should be noted that the indication bodies **20***a*, **20***b* are tools for the user to point the display surface, and are each, for example, a rod like tool imitating a writing material. However, the indication bodies **20***a*, **20***b* can each take any specific shape providing the indication bodies **20***a*, **20***b* can point the display surface. One of the indication bodies **20***a*, **20***b* corresponds to a first indication body of the embodiment of the invention, and the other thereof corresponds to a second indication body of the embodiment of the invention.

It is also possible for the detector **14** to further have a function of discriminating the indication bodies **20***a*, **20***b* indicating the positions in addition to the function of detecting the positions indicated by the indication bodies **20***a*, **20***b*. For example, in the case of the configuration in which the indication bodies **20***a*, **20***b* emit light and then the detector **14** detects the light, it is possible to discriminate the indication bodies **20***a*, **20***b* from each other based on the colors (i.e., the wavelengths) of the light with which the indication bodies **20***a*, **20***b* irradiate the display surface, or the illumination patterns (e.g., the timing of blinking) thereof.

The detector **14** can detect the plurality of positions indicated by the indication bodies **20***a*, **20***b*, respectively, and then output them as separate coordinate data. Here, the coordinate data representing the positions indicated by the indication bodies **20***a*, **20***b* are referred to as "first coordinate data" and "second coordinate data," respectively. If the detector **14** can discriminate the indication bodies **20***a*, **20***b* from each other, it is possible to make the first coordinate data and the second coordinate data have correspondence with the specific indication bodies in such a manner that, for example, the first coordinate data corresponds to the position indicated by the indication body **20***a*, and the second coordinate data corresponds to the position indicated by the indication body **20***b*.

The supply section **15** is a device for supplying the host device **30** with data via the function device **11**. The supply section **15** supplies the configuration information in the process of enumeration, and then supplies the coordinate data. Specifically, the supply section **15** assigns the first coordinate data to the first interface **11***a*, and at the same time, assigns the second coordinate data to the second interface **11***b*, and then supplies the respective data.

The host controller **31** is a device for connecting the host device **30** to the display device **10**. The host controller **31** is configured in a manner compliant with the USB standard.

The execution section **32** is a device for performing the process corresponding to the position detected by the detector **14**. The execution section **32** is capable of identifying the first coordinate data assigned to the first interface **11***a* and the second coordinate data assigned to the second interface **11***b*, and then performing the processes corresponding to the respective coordinate data. The process performed by the execution section **32** is different in accordance with the position detected by the detector **14** and the image displayed at the position by the display device **10**, but is, for example, for changing the image displayed on the display surface, or for controlling the operation of the display device **10** in accordance with the indication to the menu bar described later. The processes executed by the execution section **32** include a process of drawing a pointer and a hand-written image described later.

FIG. **2** is a diagram showing a configuration of an example of the display system **1** described above as a specific embodiment of the invention.

The projector **100** is connected to a personal computer (PC) **300** as the information processing device via an image signal cable or the like in a wired manner. The image data is input from the PC **300** to the projector **100**, and the projector **100** projects an image on the screen SC as a projection surface (the display surface) based on the image data thus input. Further, the projector **100** is connected to the PC **300** with the USB cable or the like, and transmits/receives the control data and so on to/from the PC **300**. The projector **100** can perform projection irrespective of whether the image data input from the PC **300** is a still image or a moving image. It is also possible for the projector **100** to use the wall surface itself as the screen SC besides a flat plate fixed to the wall surface. Here, the range in which the image is projected on the screen SC is defined as an actual projection area A**12** (a displayable area).

Here, the projector **100** corresponds to an example of the display device **10** shown in FIG. **1**. Further, the PC **300** corresponds to an example of the host device **30** shown in FIG. **1**, and a pen **200** corresponds to an example of the indication bodies **20***a*, **20***b* shown in FIG. **1**. It should be noted that although the pen **200** alone is shown in FIG. **2**, it is assumed that two or more pens **200** actually exist correspond respectively to two or more users.

In the display system **1**, the user can perform the operation (position indication operation) of indicating an arbitrary position in the actual projection area A**12** of the screen SC with the pen **200** in the hand during the projection of the image by the projector **100**. The pen **200** is an operation device having a pen-like shape or a rod shape, and is used for indicating an arbitrary position on the screen SC. The projector **100** has a function of detecting the position indicated by the pen **200** as described later, and outputs coordinate data (coordinate information) representing the coordinate of the position thus detected to the PC **300**.

It should be noted here that "handwriting" means that characters and figures can be drawn as if the user actually writes them with a writing material in accordance with the indication with the indication body, but does not mean that the user actually draws the characters and figures on the display surface while coloring them with color materials such as ink. It should be noted that hereinafter the characters and figures drawn by the user on the display surface are also referred collectively to "symbols." The symbols mentioned here can include numbers, signs, scientific symbols, and so on besides characters of a variety of languages. Further, figures include dots and lines besides circles and polygons.

FIG. **3** is a block diagram showing a configuration of the projector **100**.

According to a rough classification, the projector **100** is provided with a position detection unit **110** for detecting the indication position of the pen **200** on the screen SC, a coordinate conversion section **120** for converting the coordinate of the indication position detected by the position detection unit **110** into the coordinate in the image data, an image processing unit **130** for performing image processing for display based on the image data input from the PC **300**, a projection unit **140** for projecting the image on the screen SC in accordance with the control of the image processing unit **130**, an output section **150** for outputting the coordinate thus converted into by the coordinate conversion section **120**, an input section **160**, a control section **170** for controlling each of these constituents, a storage section **180**, and an operation section **190** for receiving operations by the user.

The control section **170** is composed of a central processing unit (CPU), a nonvolatile memory, a random access memory (RAM), and so on not shown, and reads out and then executes a control program stored in the storage section **180** connected to the control section **170** to thereby control each section of the projector **100**. Further, by executing the control program stored in the storage section **180**, the control section **170** performs a calibration described later. The control section **170** performs the calibration described to thereby obtain parameters (coordinate conversion parameters) representing the correspondence relationship between the coordinate in shot image data and the coordinate in the area (e.g., the actual projection area A**12**) on the screen SC to be the object of the calibration. The storage section **180** is formed of a magnetic or optical recording device, or a semiconductor storage element, and stores a variety of types of programs including the control program, and data such as various setting values.

The operation section **190** is connected to the control section **170**. The operation section **190** is provided with a variety of switches and indicator lamps, and can also be provided with an operation panel disposed on an exterior housing (not shown) of the projector **100**, or can also be provided with a receiving section for receiving an infrared signal from a so-called remote controller. The control section **170** appropriately lights or blinks the indicator lamps in accordance with the operation state and the setting state of the projector **100**. Further, when the switch of the operation section **190** is

operated, the operation signal corresponding to the switch thus operated is output to the control section **170**. It should be noted that the operation section **190** is not limited to the infrared signal, but can also have a configuration of receiving other wireless signals.

Further, in the case in which the display system **1** includes the remote controller, the projector **100** receives the infrared signal, which the remote controller (not shown) used by the user of the projector **100** transmits in accordance with the button operation. The operation section **190** receives the infrared signal received from the remote controller with a light receiving element, and then outputs an operation signal corresponding to this signal to the control section **170**. It should be noted that it is also possible to transmit an operation signal representing the operation with respect to the projector **100** from the PC **300** to the projector **100** to thereby control the projector **100** based on the operation signal. In this case, the PC **300** also functions as the operation section for the user to input the operation with respect to the projector **100**.

The control section **170** detects the operation of the user based on the operation signal input from the operation section **190**, and then controls the projector **100** in accordance with this operation.

The input section **160** is an interface for connecting the projector **100** to the PC **300**. The input section **160** is an interface for inputting image data, and there can be used therefor a general-purpose interface such as an interface to which a digital video signal is input such as a DVI (Digital Visual Interface), a USB (Universal Serial Bus) interface, or a LAN (Local Area Network) interface, the S-video terminal to which the video signal such as NTSC (National Television System Committee), PAL (Phase Alternating Line), and SECAM (Sequentiel couleur a memoire), an RCA terminal to which a composite video signal is input, a D-terminal to which a component video signal is input, or an HDMI (High-Definition Multimedia Interface, a registered trademark) connector compliant with the HDMI standard. Further, it is also possible to adopt a configuration in which the input section **160** has an A/D conversion circuit for converting an analog video signal into digital image data, and is connected to the PC **300** with an analog video terminal such as a VGA (Video Graphics Array) terminal. It should be noted that it is also possible for the input section **160** to perform transmission/reception of the image signal using wired communication, or to perform transmission/reception of the image signal using wireless communication.

Further, the input section **160** can also have a configuration provided with a DisplayPort developed by the Video Electronics Standard Association (VESA), and specifically, it can also have a configuration provided with a DisplayPort connector or a Mini-DisplayPort connector, and an interface circuit compliant with the DisplayPort standard. In this case, the projector **100** can be connected to the DisplayPort provided to the PC **300** or a portable device having an equivalent function to the PC **300**.

The configuration of the projector **100** is classified into an optical system for performing optical image formation and an image processing system for electrically processing the image signal. The optical system is composed of an illumination optical system **144**, a light modulation device **145**, and a projection optical system **146**. The illumination optical system **144** is provided with a light source formed of a xenon lamp, a super-high pressure mercury lamp, a light emitting diode (LED), a laser, or the like. Further, the illumination optical system **144** can also be provided with a reflector and an auxiliary reflector for guiding the light emitted by the light source to the light modulation device **145**, and can be a system provided with, for example, a lens group for improving the optical characteristics of the projection light, a polarization plate, or a photochromic element for reducing the light intensity of the light emitted by the light source on the path leading to the light modulation device **145**.

The light modulation device **145** receives the signal from the image processing system described later, and then modulates the light from the illumination optical system **144**. In the present embodiment, the explanation will be presented citing the case of configuring the light modulation device **145** using a transmissive liquid crystal panel as an example. In this configuration, the light modulation device **145** is composed of three liquid crystal panels corresponding respectively to the three primary colors of red (R), green (G), and blue (B) in order to perform color projection. The liquid crystal panels each have a predetermined number of pixels arranged, for example, vertically and horizontally in a matrix. The light from the illumination optical system **144** is separated into colored lights of three colors of RGB, and the colored lights enter the corresponding liquid crystal panels, respectively. The colored lights modulated while passing through the respective liquid crystal panels are combined by a combining optical system such as a cross dichroic prism, and are then output to the projection optical system **146**.

The projection optical system **146** is provided with, for example, a zoom lens for performing expansion and contraction of the image to be projected and adjustment of the focus, a zoom controlling motor for controlling the level of the zoom, and a focus adjusting motor for performing the focus adjustment.

The projection unit **140** is provided with a projection optical system drive section **143** for driving the motors provided to the projection optical system **146** in accordance with the control by the display control section **132**, a light modulation device drive section **142** for driving the light modulation device **145** based on the image signal output from the display control section **132** to thereby perform drawing, and a light source drive section **141** for driving the light source provided to the illumination optical system **144** in accordance with the control by the control section **170**. The projection unit **140** corresponds to the display section **13** shown in FIG. **1**.

On the other hand, the image processing system is formed of the image processing unit **130** for processing the image data in accordance with the control by the control section **170** for integrally controlling the whole of the projector **100**. The image processing unit **130** is provided with an image input section **131** for inputting the image data from the input section **160**, the display control section **132** for processing the image data input via the image input section **131**, and an image processing section **133** for developing the image on a frame memory **134** in accordance with the control of the display control section **132** to thereby generate the image to be projected by the projection unit **140**.

The display control section **132** performs discrimination of the format (the frame rate, the resolution, and the compression state) of the image data input via the image input section **131**, and so on to thereby determine the necessary process for displaying the display image on the light modulation device **145**, and then controls the image processing section **133** to perform the process. The image processing section **133** develops the image data, which is input via the image input section **131**, on the frame memory **134** in accordance with the control of the display control section **132**, then performs various conversion processes such as interlace/progressive conversion, or resolution conversion if necessary to thereby generate the image signal with a predetermined format for displaying the display image drawn on the frame memory **134**, and then

outputs it to the display control section **132**. It should be noted that the projector **100** can also perform the display after changing the resolution and the aspect ratio of the image data thus input, or perform the display while keeping the resolution and the aspect ratio of the image data thus input in a dot-by-dot manner. Further, the image processing section **133** can perform various types of image processing such as a keystone correction, a color compensation corresponding to a color mode, and image expansion/contraction process in accordance with the control of the display control section **132**. The display control section **132** outputs the image signal processed by the image processing section **133** to the light modulation device drive section **142** to display it on the light modulation device **145**. Further, the image processing section **133** obtains the image position information based on the information such as the resolution and the aspect ratio of the image data presently displayed, and the display size in the liquid crystal panel of the light modulation device **145**, and then outputs the image position information thus obtained to the coordinate conversion section **120**. The image position information is the information representing what position in the actual projection area A**12** the display image is projected (displayed) at. In other words, the image position information is the information related to the location of the display image in the actual projection area A**12**, and represents the position (location) of the display image in the actual projection area A**12**. The image position information varies in the case (e.g., the case in which the setting with respect to the resolution is changed in the PC **300**) in which, for example, the resolution of the image data output by the PC **300** to the projector **100** is varied due to the variation in the display resolution of the PC **300**.

The control section **170** performs the control program to thereby control the display control section **132** to execute the keystone correction of the display image imaged on the screen SC. Further, the control section **170** controls the display control section **132** to execute the expansion/contraction processes of the display image based on the operation signal input from the operation section **190**.

The projector **100** has the position detection unit **110** for detecting the indication position indicated by the pen **200** on the screen SC. The position detection unit **110** is provided with an imaging section **111** for shooting the screen SC, a shooting control section **112** for controlling the imaging section **111**, and a position detection processing section **113** for detecting the indication position of the pen **200** based on the shot image of the imaging section **111**, and a coordinate calculation section **114** for calculating the coordinate of the indication position. The position detection unit **110** corresponds to the detector **14** shown in FIG. **1**.

The imaging section **111** is a digital camera for shooting a field angle including maximum range (corresponding to the projection-allowable area A**11** described later) in which the projection unit **140** can project an image on the screen SC, and performs shooting in accordance with the control of the shooting control section **112**, and then outputs the shot image data. In other words, the imaging section **111** is set to be able to shoot the range including the entire projection-allowable area A**11**. The imaging section **111** can always shoot the display surface, and can also perform shooting at only the necessary timing in accordance with the control by the control section **170**. The shooting control section **112** controls the imaging section **111** to perform shooting in accordance with the control of the control section **170**. In the case in which the imaging section **111** has a mechanism for adjusting the zoom magnification, the focus, and the aperture in the shooting operation, the shooting control section **112** controls the mechanism to perform shooting on the conditions set previously. After the shooting operation, the shooting control section **112** obtains the shot image data output by the imaging section **111**, and then outputs it to the position detection processing section **113**. The shot image data output from the imaging section **111** can also be the data expressed in the form such as RGB or YUV, or can also be the data representing only the luminance component. Further, the shooting control section **112** can also output the shot image data, which is output from the imaging section **111**, to the position detection processing section **113** without conversion, or can also output it to the position detection processing section **113** after performing the adjustment of the resolution or the conversion into a predetermined file format (e.g., JPEG and BMP).

It should be noted that the imaging section **111** can also has a configuration capable of imaging the visible light, or a configuration capable of imaging the non-visible light (e.g., infrared light). In the case in which the imaging section **111** can image the non-visible light, it is possible to adopt, for example, the configuration in which the pen **200** emits the non-visible light, and the imaging section **111** images the non-visible light emitted from the pen **200**, and the configuration in which the pen **200** includes a reflecting section capable reflecting the non-visible light, the non-visible light is projected from the projector **100** toward the screen SC in accordance the control of the control section **170**, and then the non-visible light reflected by the reflecting section of the pen **200** is imaged by the imaging section **111**.

The position detection processing section **113** analyzes the shot image data input from the shooting control section **112** to thereby extract the boundary between the outside of the actual projection area A**12** and the actual projection area A**12** and the image of the pen **200** from the shot image data, and then identifies the indication position of the pen **200**. The indication position of the pen **200** corresponds to, for example, a position of the tip of the pen **200**. The position detection processing section **113** obtains the coordinate of the indication position thus detected, in the actual projection area A**12**.

The coordinate calculation section **114** performs the calculation of the coordinate based on the indication position of the pen **200** detected by the position detection processing section **113** and the coordinate conversion parameters. Specifically, the coordinate calculation section **114** obtains the coordinate of the indication position in the actual projection area A**12**, detected by the position detection processing section **113**, and then outputs the coordinate data representing the coordinate thus calculated to the coordinate conversion section **120**. It should be noted that in the following explanation, the data (the coordinate information) representing the coordinate is referred to as "coordinate data," or simply as a "coordinate" in some cases.

If the coordinate conversion parameters are obtained by the control section **170**, the coordinate calculation section **114** performs the conversion of the coordinate based on the coordinate conversion parameters. The conversion process will be described later. Further, the coordinate conversion section **120** converts the coordinate output from the coordinate calculation section **114** based on the image position information described later, and then outputs the coordinate thus converted into to the output section **150**.

Here, the area in the screen SC to be the object of the calibration can be the entire actual projection area A**12** or a part of the actual projection area A**12**. As the case of setting a part of the actual projection area A**12** to the object of the calibration, there can be cited the case in which the display is performed so that the vertical width of the display image of the projector **100** coincides with the vertical width of the

screen SC while the aspect ratio of the image to be displayed by the projector **100** and the aspect ratio of the screen SC are different from each other (e.g., the display resolution of the projector **100** is WXGA (with the aspect ratio of 15:9), while the aspect ratio of the screen SC is 4:3). In this case, it is possible to take the area included in the screen SC out of the actual projection area A**12** of the projector **100** as the object of the calibration, and exclude the other area from the object of the calibration. If the coordinate conversion parameters are obtained by the control section **170**, the coordinate calculation section **114** performs the conversion of the coordinate based on the coordinate conversion parameters. The conversion process will be described later. Further, the coordinate conversion section **120** converts the coordinate output from the coordinate calculation section **114** based on the image position information described later, and then outputs the coordinate thus converted into to the output section **150**.

The output section **150** is connected to the PC **300**, and outputs the coordinate data, on which the conversion process of the coordinate conversion section **120** has been performed, to the PC **300**. The output section **150** corresponds to the function device **11**, the storage section **12**, and the supply section **15** shown in FIG. **1**. In other words, the output section **150** is connected to the PC **300** in a manner compliant with the USB standard, and has two interfaces. It should be noted that the storage section **12** can also have a configuration of being formed of, for example, a part of the storage section **180** instead of the configuration of being included in the output section **150**. Further, the supply section **15** can also be one of the functions of the control section **170**.

Here, although the explanation will be presented assuming that the input section **160** and the output section **150** are functional blocks separated from each other, it is obviously possible to integrate them into a single interface. For example, it is also possible to realize both of the functions of the output section **150** and the input section **160** by a single USB interface. Further, it is also possible for the output section **150** to be connected to the image processing section **133** provided to the image processing unit **130**, and to output the coordinate, on which the conversion process of the coordinate conversion section **120** has been performed, to the image processing unit **130**. The output destination of the output section **150** is controlled by the control section **170**. The coordinate data (first coordinate data and second coordinate data) output by the output section **150** is output to the PC **300** as similar data to the coordinate data output by a pointing device such as a mouse, a trackball, a digitizer, or a pen tablet. For example, in the case in which the pen **200** is provided with a first switch **211** and a second switch **212** as shown in FIG. **5**, holding down of the first switch **211** and holding down of the second switch **212** can be assigned respectively to the operations of either one of the so-called right click and left click in a mouse and the other thereof.

Further, if the PC **300** treats the coordinate data output from the output section **150** equivalently to the coordinate data output by general-purpose pointing devices, a general-purpose device driver program corresponding to such general-purpose pointing devices can be used. In general, since such general-purpose device driver programs are previously installed as a part of the operating system (OS) of the PC **300**, it is not necessary to further install a device driver program in the case of using the general-purpose device driver program. Further, since the general-purpose device driver program is used, it is not necessary to prepare a dedicated device driver program on the one hand, but the information which can be exchanged between the projector **100** and the PC **300** is limited to the range determined by the specification of the general-purpose device driver program on the other hand.

Further, it is also possible to prepare the dedicated device driver program corresponding to the projector **100**, and then use the device driver program after installing it on the PC **300**. In this case, the dedicated device driver program is required on the one hand, and the information which can be exchanged between the projector **100** and the PC **300** can arbitrarily be set in accordance with the specification of the dedicated device driver program.

FIG. **4** is a block diagram showing a configuration of the PC **300**. As shown in FIG. **4**, the PC **300** is provided with a CPU **310** for executing a control program to centrally control each part of the PC **300**, a ROM **320** storing a basic control program to be executed by the CPU **310** and the data related to the program, a RAM **330** for temporarily storing the programs to be executed by the CPU **310** and the data, a storage section **340** for storing the programs and the data in a non-volatile manner, an input section **350** for detecting input operations and outputting data and operation signals representing the input content to the CPU **310**, a display section **360** for outputting display data for displaying the processing result or the like by the CPU **310**, and an external I/F **370** for transmitting/receiving the data and so on to/from an external device, and these sections are connected to each other through a bus.

The input section **350** has an input I/F **380** having a connector and a power supply circuit, and an input device **381** is connected to the input I/F **380**. The input I/F **380** corresponds to the host controller **31** shown in FIG. **1**, and the input device **381** corresponds to, for example, a keyboard or a pointing device such as a mouse or a digitizer.

A USB cable coupled to the projector **100** is connected to the input I/F **380**, and the coordinate of the indication position by the pen **200** is input from the projector **100** to the input I/F **380**. Here, the coordinate data output by the output section **150** of the projector **100** is input to the input I/F **380** as the similar data to the coordinate data output by a pointing device such as a mouse, a trackball, a digitizer, or a pen tablet. Therefore, the PC **300** can process the coordinate data input from the projector **100** as an input signal from the input device, and can perform an operation of, for example, performing the translation of a mouse cursor or a pointer based on the coordinate data.

The display section **360** has an image output I/F **390** provided with a connector for outputting the image signal, a monitor **391** and an image signal cable (not shown) to be coupled to the projector **100** are connected to the image output I/F **390**. The image output I/F **390** is provided with, for example, a plurality of VGA (Video Graphics Array) terminals for outputting an analog video signal, DVI interfaces, USB interfaces, and LAN interfaces for outputting a digital video signal, S-video terminals for outputting a video signal such as NTSC, PAL, or SECAM, RCA terminals for outputting a composite video signal, D-terminals for outputting a component video signal, and HDMI connectors compliant with the HDMI standard, and the monitor **391** and the projector **100** are connected respectively to these connectors. Further, there can also be adopted a configuration in which the image output I/F **390** is provided with a DisplayPort developed by VESA, and specifically, there can also be adopted a configuration in which the image output I/F **390** is provided with the DisplayPort connector or the Mini-DisplayPort connector and an interface circuit compliant with the DisplayPort standard. In this case, the PC **300** can output the digital video signal to the projector **100**, the monitor **391**, or other devices via the DisplayPort. It should be noted that it is also possible

for the image output I/F **390** to perform transmission/reception of the image signal using wired communication, or to perform transmission/reception of the image signal using wireless communication.

The storage section **340** stores a display control program to be executed by the CPU **310**, and image data to be output when executing the display control program. When executing the display control program, the CPU **310** performs a process of transmitting the image data to the projector **100**. In this process, the CPU **310** reproduces the image data, and at the same time makes the display section **360** generate the image signal with a predetermined display resolution and then output it to the image output I/F **390**. Here, the display section **360** outputs the analog image signal to a connector for outputting an analog signal, and outputs the digital image data to a connector for outputting digital data.

Further, the CPU **310** generates an image for displaying the pointer P**1** (FIG. **2**) at a position corresponding to the coordinate corresponding to an operation of the pen **200** when the coordinate is input from the input section **350** during the execution of the display control program. Then, the CPU **310** generates the image data having the pointer P**1** superimposed on the image data presently reproduced, and then outputs the image data from the image output I/F **390** to the projector **100**. Further, as described later, the CPU **310** performs setting and control with respect to the display in the handwriting area. In other words, in the present embodiment the control section **310** realizes a function corresponding to the execution section **32** shown in FIG. **1**.

As described above, in the display system **1**, the PC **300** performs the function of drawing the pointer P**1** superimposed on the image data output by the PC **300** to the projector **100**.

FIG. **5** is a diagram showing an example of an appearance of the pen **200**. The pen **200** is provided with the first switch **211** and the second switch **212**. The first switch **211** is disposed on the tip of the pen **200**, and is a switch configured so that the user can hold down the switch by pressing the pen **200** against the screen SC. On the other hand, the second switch **212** is disposed on the shaft of the pen **200** so as to be able to be held down. The first switch **211** and the second switch **212** each can function like a button of a mouse. Further, the tip of the first switch **211** is provided with an opening, and is configured so that light (visible light or non-visible light) is emitted through the opening.

FIG. **6** is a block diagram showing a configuration of the pen **200**. The pen **200** is provided with an operation section **210** having the first switch **211** and the second switch **212**, and for outputting an operation signal corresponding to the operation of the user, an irradiation control section **220** for controlling the irradiation condition of the light in accordance with the operation signal from the operation section **210**, and an irradiation section **230** for irradiating an object with the light in accordance with the control by the irradiation control section **220**. The irradiation control section **220** varies the irradiation pattern (e.g., the period of lighting or extinction, the intervals, and the intensity) of the light in accordance with the operation of the user. The irradiation section **230** has a light source such as an LED or a laser diode. The light with which the irradiation section **230** irradiates an object can be either of visible light and non-visible light (e.g., infrared light).

In the present embodiment, the number of the pens **200** existing corresponds to the number of the users, namely a plurality of the pens **200** exists. In the present embodiment, each of the pens **200** is configured to be optically discriminated from each other. The pens **200** can be configured so as to be discriminated from each other by making the irradiation patterns of the light different from each other. Further, in the case in which the imaging section **111** is capable of imaging visible light, the pens **200** can also be discriminated by making the wavelengths (i.e., the colors) of the light, with which the object is irradiated, different from each other, or can also be discriminated by providing images such as barcodes or ID to the housing of the pens **200** with printing or labels, and then analyzing the shot image data obtained by shooting the images. Such image analysis can be performed by the position detection processing section **113**.

FIGS. **7**A and **7**B are diagrams showing an example of projecting an image on a screen SC by the projector **100**, wherein FIG. **7**A shows a state of projecting the pointer P**1** in accordance with the indication position of the pen **200**, and FIG. **7**B shows the state in which a hand-written image H**1** is drawn in accordance with the indication position.

In this example, if the display image is projected using the entire liquid crystal panel provided to the light modulation device **145**, the image is formed in the projection-allowable area A**11** indicated by the dashed-two dotted line in FIG. **7**A. Since the keystone distortion is generated in the projection-allowable area A**11** as shown in FIG. **7**A except the case in which the projector **100** is located right in front of the screen SC, the projector **100** performs the keystone correction due to the function of the display control section **132**. After performing the keystone correction, the display image is projected in the actual projection area A**12** as a part of the projection-allowable area A**11**. The actual projection area A**12** is normally set so as to have a rectangular shape on the screen SC, and have the maximum size within the projection-allowable area A**11**. Specifically, the actual projection area A**12** is determined based on the resolution of the liquid crystal panel of the light modulation device **145** and the level of the keystone distortion, and is not necessarily required to have the maximum size. It should be noted that if the keystone distortion does not occur in the image projected from the projector **100**, execution of the keystone correction is not required. In this case, the actual projection area A**12** coincides with the projection-allowable area A**11**.

The control section **170** of the projector **100** performs the calibration to the actual projection area A**12** on which the keystone correction has been performed. In the calibration, the control section **170** controls the image processing section **133** to draw a predetermined image for calibration. In the state in which the image for calibration is projected on the screen SC, the position detection unit **110** shoots the screen SC under the control of the control section **170**. The image for calibration is, for example, an image with some dots arranged on the white background, and is stored in advance in the storage section **180** and so on. It should be noted that the image for calibration is not necessarily required to be stored in the storage section **180** or the like, it is also possible to adopt the configuration in which the control section **170** generates the image for calibration on a case-by-case basis every time necessity of the execution of the calibration arises and the calibration is executed.

The area in the screen SC to be the object of the calibration can be the entire actual projection area A**12** or apart of the actual projection area A**12**. As the case of setting a part of the actual projection area A**12** to the object of the calibration, there can be cited the case in which the display is performed so that the vertical width of the display image of the projector **100** coincides with the vertical width of the screen SC while the aspect ratio of the image to be displayed by the projector **100** and the aspect ratio of the screen SC are different from each other (e.g., the display resolution of the projector **100** is WXGA (with the aspect ratio of 15:9), while the aspect ratio

of the screen SC is 4:3). In this case, it is possible to take the area included in the screen SC out of the actual projection area A12 of the projector 100 as the object of the calibration, and exclude the other area from the object of the calibration.

The control section 170 detects the outline of the display image in the shot image data, namely the boundary between the outside of the actual projection area A12 and the actual projection area A12, and the dots in the shot image data, and then identifies the correspondence relationship between positions in the shooting range (field angle) of the position detection unit 110, namely the positions in the shot image, and positions on the actual projection area A12. The control section 170 obtains the coordinate conversion parameters to be used by the coordinate calculation section 114 as described later based on the correspondence relationship between the positions on the shot image and the positions on the actual projection area A12 identified by the calibration. The coordinate conversion parameters include, for example, the data for making the coordinate on the image drawn by the image processing section 133 and the coordinate obtained on the shot image data correspond to each other. The coordinate calculation section 114 can convert the coordinate obtained on the shot image data into the coordinate on the image drawn by the image processing section 133 based on this coordinate conversion parameter. The coordinate calculation process is performed based on this coordinate conversion parameter.

Since the calibration is performed by the control section 170 executing a calibration program (not shown) stored in the storage section 180, it is not required to install and execute the calibration program in the PC 300. Further, the calibration can be the process automatically performed by the control section 170 based on the shot image data, or can be the process requiring an operation of the user to the image for calibration. Further, it is also possible for the calibration to be performed by using both of these processes. As the operation by the user to the image for calibration, there can be cited, for example, an operation of the user to indicate the dot included in the image for calibration with the pen 200.

The position detection unit 110 provided to the projector 100 performs the shooting in the state in which the image is projected in the actual projection area A12, virtually sets the Cartesian coordinate system in the shot image taking either one of the vertexes of the actual projection area A12 as the origin as indicated by the dotted arrows in the drawings, and obtains the coordinate of the tip position of the pen 200 in the coordinate system. The Cartesian coordinate system is set based on the coordinate conversion parameters, which can be obtained by the calibration described above. Subsequently, when the coordinate of the tip of the pen 200 in the image data displayed in the actual projection area A12 is obtained by the coordinate conversion section 120, the pointer P1 and the menu bar M1 shown in FIG. 7A, for example, are displayed in accordance with the coordinate. The pointer P1 is drawn as a symbol indicating the tip position of the pen 200. The pointer P1 can be an image of a simple dot, or can also be an image of a cross or an arrow. Further, the menu bar M1 is a graphical user interface (GUI) widget, which can be operated by the pen 200, and it becomes possible for the user to perform operations related to the operation of the projector 100 by indicating the buttons disposed in the menu bar M1 with the pen 200. Here, the operations which can be performed by the menu bar M1 include, for example, drawing of a symbol such as a line, storing, deleting, and copying of a hand-written image drawn, translation of the operation image drawn, an operation (undo) of undoing the last operation, and an operation (redo) of redoing the operation undone by the undo operation.

As a specific example, by moving the pen 200 from the position shown in FIG. 7A to the position in FIG. 7B, the hand-written image H1 is drawn along the trajectory of the tip of the pen 200. The hand-written image H1 is an image, which the PC 300 makes the projector 100 draw in accordance with the coordinate data representing the indication position of the pen 200 similarly to, for example, the pointer P1 and the menu bar M1. Further, it is possible for the user to set the color and the thickness of the line of the hand-written image H1 by indicating the menu bar M1 before drawing the hand-written image H1.

Further, in the menu bar M1, there can be disposed a button for controlling the slide show display for sequentially displaying a plurality of images (e.g., image data stored by an external storage device such as a USB flash memory connected to the input section 160) which can externally be supplied, a button for executing setting (e.g., change in the aspect ratio and change in the color mode) related to the function itself of the projector 100, and so on. In other words, the operations performed by the menu bar M1 can include those having no direct relation with drawing of a hand-written image. In the case in which the indication position of the pen 200 is output from the coordinate conversion section 120, the control section 170 obtains the coordinate to identify the button indicated in the menu bar M1, and then executes the operation corresponding to the indication operation.

FIGS. 8A and 8B are explanatory diagrams showing how the projector 100 performs the process of detecting the coordinate of the indication position, and then converting it into the coordinate in the image data, wherein FIG. 8A shows the initial state of the series of operations, and FIG. 8B shows the state in which the resolution of the display image has been changed from the state shown in FIG. 8A. It should be noted that in the following explanation, there will be explained the case in which no keystone distortion occurs in the image projected by the projector 100, and the image displayed in the entire modulation area of the light modulation device 145 is displayed in the actual projection area A12. In this case, the actual projection area A12 coincides with the projection-allowable area A11, and the resolution of the image displayed in the actual projection area A12 is equal to the resolution of the liquid crystal panel of the light modulation device 145.

In the example shown in FIG. 8A, the resolution of the liquid crystal panel of the light modulation device 145 and the resolution of the image displayed in the actual projection area A12 are both 1280×800 dots. Further, the resolution of the image data input from the PC 300 is also 1280×800 dots. Therefore, in the actual projection area A12, the display image I11 with the resolution of 1280×800 dots is displayed. The position detection unit 110 sets the X-Y Cartesian coordinate system taking the upper left corner of the actual projection area A12 as the origin, the rightward direction as the X-axis positive direction, and the downward direction as the Y-axis positive direction, and detects the coordinate (X1n, Y1n) of the indication position of the pen 200 in the actual projection area A12. The coordinate data output by the coordinate calculation section 114 represents the coordinate (X1n, Y1n) of the indication position.

The coordinate (X1n, Y1n) of the indication position is a coordinate (normalized coordinate) normalized in the actual projection area A12. Specifically, the coordinate X1n of the indication position in the X-axis direction represents the ratio of the length WP1 from the left side of the actual projection area A12 to the indication position with respect to the lateral width W1 of the actual projection area A12. Further, the coordinate Y1n of the indication position in the Y-axis direction represents the ratio of the length HP1 from the upper side

of the actual projection area A12 to the indication position with respect to the vertical width H1 of the actual projection area A12. It should be noted here that the values W1, WP1, H1, and HP1 are expressed with the number of pixels.

In this case, the coordinate (X1n, Y1n) is calculated by the formulas 1, 2 described below.

$$X1n=WP1\div W1 \quad (1)$$

$$Y1n=HP1\div H1 \quad (2)$$

For example, in the example shown in FIG. 8A, WP1=400 and HP1=300 are assumed. Since the resolution of the display image I11 is 1280×800 dots, W1=1280 and H1=800 are true. Therefore, the expressions of X1n=400÷1280≈0.313 and Y1n=300÷800=0.375 can be obtained. Further, in this case, the coordinates of the upper left vertex of the actual projection area A12, the upper right vertex thereof, the lower left vertex thereof, and the lower right vertex thereof are expressed as (0, 0), (1, 0), (0, 1), and (1, 1), respectively. It should be noted that in the state shown in FIG. 8A since the actual projection area A12 and the area in which the display image I11 is displayed coincide with each other, the coordinates (X1n, Y1n) can also be regarded as the coordinates normalized in the display image I11. It should be noted that although in the present embodiment the normalization of the coordinate is performed on both of the coordinate (X1n, Y1n) and the coordinate (X2n, Y2n) within the range equal to or higher than 0 and equal to or lower than 1, the method of normalization is not limited thereto. For the normalization of the coordinate, there can be used an arbitrary value (e.g., the range equal to or higher than 0 and equal to or lower than 32767) defined logically.

Here, if the image data input from the PC 300 is switched to the display image 112 with the resolution of 1024×768 dots, the projector 100 scales the image data so that the vertical resolution (768 dots) of the image data is increased to the vertical resolution (800 dots) of the liquid crystal panel. Since the scaling is performed in both of the vertical direction and the horizontal direction in a similar manner, the horizontal resolution (1024 dots) of the image data is scaled to 1024×(800÷768)≈1066 dots. As a result, as shown in FIG. 8B, the display image 112 with the resolution of 1066×800 dots is projected on the screen SC. Since the aspect ratio and the resolution of the display image 112 are different from the aspect ratio and the resolution of the display image I11, the area in which the display image 112 is projected does not coincide with the actual projection area A12. In the example shown in FIG. 8B, the area in which the display image 112 is projected is smaller than the actual projection area A12. Further, the projector 100 changes the position thereof so that the image thus scaled is displayed at a position near to the center as much as possible. Therefore, in the actual projection area A12, the position of the upper left vertex of the display image I11 and the position of the upper left vertex of the display image 112 do not coincide with each other.

Here, as shown in FIGS. 8A and 8B, when switching the display image I11 to the display image 112 in the state in which the pen 200 on the screen SC is fixed, the relative position between the indication position and the image displayed varies although the indication position itself is not moved. Therefore, the coordinate (X1n, Y1n) of the indication position normalized taking the upper left vertex of the display image I11 as the origin and the coordinate (X2n, Y2n) of the indication position normalized taking the upper left vertex of the display image 112 as the origin are different from each other. Therefore, if the pointer P1 is displayed based on the coordinate (X1n, Y1n) of the indication position in the actual projection area A12, which the position detection unit 110 has calculated based on the shot image data of the imaging section 111, the pointer P1 is shifted from the actual indication position.

In the example shown in FIG. 8B, for example, the upper left vertex of the display image 112 is located at a position shifted 107 (=(1280−1066)÷2) pixels rightward from the upper left vertex of the display image I11. Therefore, defining that the length from the left side of the display image 112 to the indication position is WP2, and the length from the upper side of the display image 112 to the indication position is HP2, WP2=WP1−107=400−107=293 and HP2=HP1=300 are obtained. Further, since the resolution of the display image 112 is 1066×800 dots, the lateral width W2 and the vertical width H2 of the display image 112 are W2=1066 and H2=800, respectively. Therefore, the coordinate (X2n, Y2n) of the indication position normalized taking the upper left vertex of the display image 112 as the origin is expressed as X2n=(400−107)÷1066≈0.275, Y2n=300÷800=0.375. As described above, X1n≠X2n is resulted, and if the resolution of the display image is changed, the normalized coordinate of the indication position is also changed.

Therefore, if the pointer P1 is displayed at the coordinate (X1n, Y1n)=(0.313, 0.375) in the coordinate system taking the upper left corner of the display image 112 having been changed as the origin, a pointer P1*a* is displayed at the position separate from the tip of the pen 200. This is because the PC 300 performs the drawing taking the upper left of the image as the origin based on the normalized coordinate output from the position detection unit 110 when drawing the pointer P1. As described above, since the coordinate obtained taking the actual projection area A12 as a reference is affected by the resolution of the display image, it is not achievable for the PC 300 to directly use the coordinate calculated by the position detection unit 110 for the display of the pointer P1.

Therefore, the projector 100 performs the process of converting the coordinate (X1n, Y1n) of the indication position calculated by the coordinate calculation section 114 of the position detection unit 110 into the coordinate (X2n, Y2n) of the indication position in the display image presently displayed using the coordinate conversion section 120 so as to be able to cope with the case in which the resolution of the display image has changed.

The coordinate conversion section 120 converts the coordinate (X1n, Y1n) into the coordinate (X2n, Y2n) based on the image position information input from the image processing section 133. The image position information is the information related to the configuration of the image in the modulation area of the light modulation device 145. Further, the modulation area of the light modulation device 145 corresponds to the actual projection area A12 on the screen SC. Therefore, the image position information represents the position (configuration) of the display image with respect to the actual projection area A12. In the present embodiment, the image position information represents the position (configuration) and the size of the display image with respect to the actual projection area A12. Based on the image position information, the coordinate conversion section 120 obtains the coordinate of the indication position in the display image. For example, in the example shown in FIGS. 8A and 8B, the values W1, H1, W2, and H2 correspond to the image position information. Further, the coordinate (XO1, YO1)=(0, 0) of the upper left end of the display image I11 and the coordinate (XO2, YO2)=(107, 0) of the upper left end of the display image 112 also correspond to the image position information. It should be noted that the coordinates XO1, YO1, XO2, and YO2 are not the normalized coordinates, but are those repre-

senting the positions of the upper left vertex of the display image with the number of pixels taking the upper left vertex (or the upper left vertex of the modulation area of the light modulation device **145**) of the actual projection area A**12** as the origin in the actual projection area A**12** (or the modulation area of the light modulation area **145**). In the example shown in FIGS. **8**A and **8**B, the image position information of the display image I**11** (XO**1**, YO**1**, W**1**, H**1**)=(0, 0, 1280, 800) is obtained, and the image position information of the display image **112** (XO**2**, YO**2**, W**2**, H**2**)=(107, 0, 1166, 800) is obtained.

The coordinate (X**2**n, Y**2**n) calculated by the coordinate calculation section **114** can be used as the information for identifying the position in the image data when the PC **300** draws the pointer P**1**, the menu bar M**1**, or the hand-written image H**1** in the image data as the processing object. Therefore, the pointer P**1**, the menu bar M**1**, and the hand-written image H**1** can accurately be drawn in accordance with the indication position by the pen **200** without being affected by the resolution of the display image, the zooming ratio, and so on.

Incidentally, the position and the size of the display image displayed in the actual projection area A**12** are affected by the resolution and the display position of the display image. For example, in the case in which the projector **100** performs the process of changing the projection state such as change in the display resolution, change in the aspect ratio, zooming, change (translation) in the display position of the image, or multi-screen display process in accordance with an operation by the operation section **190**, or a control signal transmitted from the PC **300**, the image position information is also changed. As described above, the image position information is the information related to the configuration of the image placement area (the area in which the display images I**11**, I**12** are projected (displayed)) with respect to the actual projection area A**12**. In other words, the image position information is the information representing the position (configuration) of the display image with respect to the actual projection area A**12** (the display-allowable area). Further, the image position information also varies in the case (e.g., the case in which the setting with respect to the resolution is changed in the PC **300**) in which the display resolution of the PC **300** is varied, and the resolution of the image data output by the PC **300** to the projector **100** is varied. It should be noted that the "multi-screen display process" denotes the process of dividing the actual projection area A**12** of the projector **100** into a plurality of areas, and displaying the images different from each other respectively input from a plurality of image supply devices in the respective areas.

The coordinate conversion section **120** obtains the information from the control section **170** and the display control section **132** to update the image position information, and then converts the coordinate based on the image position information thus updated every time the projection state (the display state) of the display image by the projection unit **140** is varied. The image position information is updated at, for example, the timings cited below.

The control section **170** has detected the input of the image data from the PC **300**.

The control section **170** has detected the change in the information (e.g., the resolution of the image) related to the image data input from the PC **300**.

The resolution of the image data has changed in the projector **100**.

The aspect ratio of the image data has changed in the projector **100**.

The digital zoom function of expanding/contracting the image to be drawn by the light modulation device **145** using the image processing of the image data to be projected has been executed or terminated.

The display position of the display image with respect to the actual projection area A**12** has been changed.

The image has been enlarged by the digital zoom function described above, and then the function of changing the display position of the image using the image processing has been executed or terminated.

The Tele/Wide function for expanding/contracting the projection size of the whole including the image drawn by the light modulation device **145** and the background, namely the entire actual projection area A**12**, by performing the image processing on the image data has been executed or terminated.

The image has been contracted by the digital zoom function described above, and then the picture shift function of changing the display position of the image using the image processing has been executed or terminated.

The simultaneous display of a plurality of images has been executed or terminated.

The output destination to which the coordinate is output from the coordinate conversion section **120** has been changed from the image processing unit **130** to the PC **300** (the output section **150**) or vice versa.

The change in the resolution, the change in the aspect ratio, and the execution and termination of the variety of functions are all executed by the image processing unit **130** under the control of the control section **170**. It should be noted that the timings cited above are nothing more than examples, and it is obviously possible to update the image position information at other timings.

FIG. **9** is a flowchart showing the operation of the projector **100**, and in particular showing the operation of detecting the indication position by the pen **200** and then outputting the coordinate of the indication position.

After the start-up of the projector **100** or in the case in which display of the pointer P**1** or the menu bar M**1** is instructed by the operation of the operation section **190**, the operation shown in FIG. **9** is repeatedly executed at regular intervals until the projection is terminated.

Firstly, whether or not the calibration is necessary is determined (step S**11**). This determination can also be performed based on the instruction of the user expressing whether or not the calibration is necessary, or it is also possible that the control section **170** automatically determines whether or not the calibration is necessary to be performed, and the determination is performed automatically based on the determination result. If the calibration is necessary (YES in the step S**11**), the calibration is performed (step S**12**) as explained with reference to FIG. **7**A. Specifically, by making the image processing section **133** draw the image for calibration, making the position detection unit **110** perform shooting in the state in which the image for calibration is projected, and then detecting the outline of the actual projection area A**12** in the shot image data thus obtained and the characteristic points (e.g., the dots) included in the image for calibration, the correspondence relationship between the image drawn by the image processing section **133** and the shot image data is obtained. It should be noted that it is sufficient to perform the calibration once after starting the use of the projector **100**, and it is not necessary to perform the calibration once again unless a specific event occurs. It is necessary to newly perform the calibration in, for example, the cases 1 through 3 below.

1. The keystone correction has been performed.

2. The installation conditions of the projector **100** have changed. For example, the relative position (including the orientation) of the projector **100** with respect to the screen SC has changed.

3. Optical conditions have changed. For example, the state of focus or zoom of the projection optical system **146** has changed. The optical axis of the projection optical system **146** or the imaging section **111** is shifted due to temporal change thereof and so on.

If any of these events occurs, since the correspondence relationship between the position on the shot image data and the position on the image drawn by the image processing section **133** in the initial state, which forms the basis for the coordinate conversion section **120** to calculate the coordinate, is changed (in other words, the coordinate conversion parameters are varied), it is necessary to newly perform the calibration. In contrast, since it is not necessary to perform the calibration once again unless any of these events occurs, if the events described above have not occurred during the period from when the projector **100** is used previously to when the projector **100** is used this time, the coordinate conversion parameters obtained in the previous calibration can also be reused without newly performing the calibration. As the method for the control section **170** to determine whether or not the calibration is necessary to be performed, there can be cited, for example, a method of making the determination based on the presence or absence of the operation of the switch instructing the execution of the keystone correction in the operation section **190**, and a method of providing a sensor for detecting the tilt and the movement to the projector **100**, and making the determination based on the variation in the detection value of the sensor. Further, it is also possible for the control section **170** to automatically perform the calibration if the focus adjustment or the zoom adjustment in the projection optical system **146** is performed. Further, it is also possible to provide a dedicated switch to the operation section **190** or the remote controller so that the user figures out the change in the installation position of the projector **100** and the optical conditions, and can perform the operation of instructing the execution of the calibration.

When the shooting control section **112** makes the imaging section **111** shoot the range including the actual projection area **A12** under the control of the control section **170**, the position detection processing section **113** obtains (step **S13**) the shot image data, and then detects (step **S14**) the indication position of the pen **200** based on the shot image data. Subsequently, the coordinate calculation section **114** calculates (step **S15**) the coordinate of the indication position detected by the position detection processing section **113**. The coordinate calculated in the step **S15** is the coordinate in the actual projection area **A12**, and corresponds to the coordinate (X**1**n, Y**1**n) explained with reference to FIG. **8**A.

The coordinate conversion section **120** determines (step **S16**) whether or not the update of the image position information is necessary, and then obtains the information from the control section **170** and the display control section **132**, and updates (step **S17**) the image position information if the update is necessary. The timing of the process of the step **S17** is not limited to the posterior stage of the step **S15**, but the process of the step **S17** can also be performed at the timings described above as an example.

Subsequently, the coordinate conversion section **120** performs (step **S18**) the process for converting the coordinate calculated by the coordinate calculation section **114** into the coordinate in the image data of the display image. The coordinate thus converted corresponds to the coordinate (X**2**n, Y**2**n) explained with reference to FIG. **8**B.

The coordinate conversion section **120** outputs (step **S19**) the coordinate thus converted to the PC **300**, and then terminates the present process.

As described above, in the display system **1**, the projector **100** is provided with the projection unit **140** for displaying the display image on the screen SC based on the image data, the position detection processing section **113** for detecting the indication position with respect to the display image on the screen SC, the coordinate calculation section **114** for calculating first coordinate information, which is the coordinate of the indication position in the display-allowable area (e.g., the actual projection area **A12**) on the screen SC, the coordinate conversion section **120** for converting the first coordinate information calculated by the coordinate calculation section **114** into second coordinate information, which is the coordinate in the image data, and the output section **150** for outputting the second coordinate information obtained by the coordinate conversion section **120**, and outputs the coordinate of the indication position by the pen **200** as the coordinate in the image data, and therefore, it is possible to identify the relative position between the indication position and the image data in the PC **300** and so on, which use the coordinate thus output, without being affected by the display configuration such as the display resolution or the size of the display area. Since it is not necessary to make the image data itself and the indication position directly correspond to each other in the process of obtaining the coordinate of the indication position in the image data, it is not necessary to perform the calibration even if the change in size and so on of the image data occurs. Therefore, the execution frequency of the calibration can be reduced. Thus, enhancement of the convenience of the projector **100** can be achieved. Further, since it is not necessary to execute the program for the calibration on the PC **300** side, the load to the user unfamiliar with the operation of the PC **300** can be reduced.

Further, since the coordinate conversion section **120** converts the first coordinate information calculated by the coordinate calculation section **114** into the second coordinate information based on the image position information, which is the information representing the position of the display image with respect to the display-allowable area, even if the image position information, which is the information representing the position of the display image with respect to the display-allowable area, is varied, the coordinate conversion section **120** can accurately convert the coordinate of the indication position by the pen **200**, and then output the result.

Further, the coordinate conversion section **120** converts the first coordinate information calculated by the coordinate calculation section **114** into the second coordinate information based on the resolution of the image data. For example, the coordinate conversion section **120** performs the conversion of the coordinate using the image position information reflecting the display resolution of the projection unit **140** and the resolution of the image data. Thus, the coordinate of the indication position can correctly be converted and then output even if the resolution of the image data varies.

Further, the position detection unit **110** detects the position of the pen **200** on the screen SC based on the shot image shot by the imaging section **111** to thereby detect the indication position in the actual projection area **A12**, and can therefore detect the indication position promptly.

Further, if the coordinate of the indication position calculated by the coordinate calculation section **114** is not included in the area where the image data is displayed, in other words, if the indication position is not included in the display image,

the coordinate conversion section **120** sets the coordinate of the position, which is included in the area where the display image is displayed, and is near to the indication position, to the coordinate obtained by the conversion. Therefore, it is possible to output the coordinate of the indication position even in the case in which the position where the image is not displayed is indicated. Further, the coordinate output therefrom is the coordinate of the position near to the indication position, and can therefore be processed by the PC **300** and so on similarly to the case of the coordinate of the indication position.

Further, it is also possible for the coordinate conversion section **120** to refrain from outputting the coordinate thus converted in the case in which the coordinate of the indication position calculated by the coordinate calculation section **114** is not included in the area where the image data is displayed, in other words, in the case in which the indication position is not included in the display image, and in this case, the PC **300** can perform the operation corresponding only to the indication to the position overlapping the image.

Further, if the process on the image data is performed by the display control section **132** and so on, and thus, the display configuration of the image on the screen SC is changed, the coordinate conversion section **120** performs the process of converting the coordinate based on the image position information thus varied in accordance with the display configuration. The coordinate thus newly converted here is output by the output section **150**. Thus, it is possible to always output an appropriate coordinate in accordance with the variation in the display configuration of the display image.

As described above, according to the display system **1** of the present embodiment, by constituting the two interfaces in the output section **150**, and then assigning the same class to these interfaces, it becomes possible to identify these interfaces in the PC **300** while transmitting the coordinate data of the two pens **200** with a single USB cable. Therefore, it is possible for the PC **300** to identify the two pens **200** without occupying a plurality of ports. Therefore, even in the case in which a plurality of users performs hand writing operations at the same time using the respective pens **200**, it is possible to display the pointer P**1** and the hand-written image H**1** corresponding to each of the indication positions. Further, since a general-purpose HID class is assigned to the two interfaces, it becomes unnecessary for the user to install a dedicated device driver on the PC **300**.

The invention is not limited to the embodiments described above, but can be put into practice in a variety of aspects exemplified below. Further, the invention can also be put into practice in the aspects obtained by combining the modified examples described below if necessary.

In the invention, the number of indication bodies is not limited. Specifically, in the invention, it is also possible to use three or more indication bodies at the same time. In this case, in the display device, the function device can be configured so as to have the same number of interfaces as the number of the indication bodies, and to assign the same class to these interfaces. It should be noted that among the pointing devices such as a mouse or a digitizer, the device having a high possibility of coping with different use environments (e.g., the case in which the PC **300** are different in OS) is mouse, and therefore, it is preferable to assign the class corresponding to mouse when assigning the same class to the plurality of interfaces.

In the projector according to the embodiment of the invention, it is also possible to realize the whole or a part of the constituent corresponding to the position detection unit **110** with another device. For example, the projector according to the embodiment of the invention can be configured so that a digital camera having a function corresponding to the imaging section **111** and the shooting control section **112** can be connected thereto, and can be a device of obtaining the shot image data from the digital camera. Further, the position detection unit **110** can also be a device other than the projector **100** or the PC **300**. In this case, a device separated from the projector **100** can be used as the position detection unit **110**. Further, in this case, the position detection unit **110** can be provided with the function corresponding to the coordinate conversion section **120**.

Although in the embodiment section described above, the explanation is presented citing the configuration in which the display device **10** and the host device **30** are separated from each other as an example, it is also possible to adopt the configuration in which the display device **10** has the host device **30** in the inside thereof. In this case, the display device **10** is also provided with the function of the execution section **32**.

Although in the embodiment section described above the explanation is presented citing the configuration using the pen **200** as the indication body as an example, it is also possible to use an indication body other than the pen **200**. For example, it is also possible to use a finger of the user as the indication body.

The pen **200** can be provided with the configuration in which the irradiation section **230** does not irradiate the object with the light if the first switch **211** and the second switch **212** are not held down, and the irradiation section **230** irradiates the object with the light if the first switch **211** or the second switch **212** is held down. Further, it is also possible for the pen **200** to always irradiate the object with the light with the irradiation section **230**, and change the irradiation pattern of the light between the case in which the first switch **211** or the second switch **212** is held down and the case in which it is not held down. In either of the cases, whether or not the first switch **211** or the second switch **212** is held down (whether or not the first switch **211** or the second switch **212** is operated) can be detected by analyzing the image shot by the imaging section **111**. Further, the projector **100** can also output operation information (first operation information) representing the fact that the first switch **211** or the second switch **212** is held down (operated), and operation information (second operation information) representing the fact that holding down of the first switch **211** or the second switch **212** is terminated (the operation is terminated) to the PC **300**. For example, the projector **100** can also output the first operation information to the PC **300** as the information representing the fact that the mouse is clicked on the left button, and output the second operation information to the PC **300** as the information representing the fact that the left click of the mouse is terminated. Further, the projector **100** can also output such information to the PC **300** together with the identification information for identifying the pens **200**, and the coordinate information of each of the pens **200**. Further, the projector **100** can also output the operation information to the PC **300** as the information representing the operation of a pointing device (e.g., a digitizer) other than the mouse.

The control data such as the coordinate information or the identification information can be output from the projector **100** to the PC **300** with the USB communication. Further, the projector **100** can also output the control data to the PC **300** with Bluetooth (registered trademark), a LAN, and so on.

The display device according to the embodiment of the invention is not required to be a projector. For example, the display device according to the embodiment of the invention can also be a liquid crystal display. In this case, the constituent corresponding to the detector **14** can also be a digital still

camera or the like, but can also be realized by a touch screen (a touch panel) disposed so as to overlap the display surface. Further, as the detector **14**, a variety of constituents well known to the public can be used besides the touch screen. It should be noted that in the case in which the display device according to the embodiment of the invention has the display surface itself, the operation such as the calibration described above becomes unnecessary.

Although in the embodiment described above the explanation is presented citing, as an example, the configuration in which the light modulation device **145** uses the three transmissive or reflective liquid crystal panels corresponding to the respective colors of RGB as means for modulating the light emitted by the light source, the invention is not limited thereto, but can be configured using a system including one liquid crystal panel and a color wheel combined with each other, a system using three digital mirror devices (DMD), a DMD system using one digital mirror device and a color wheel combined with each other, and so on. Here, in the case of using just one liquid crystal panel or DMD as the display section, the member corresponding to the combining optical system such as the cross dichroic prism is not necessary. Further, besides the liquid crystal panel or the DMD, any configuration capable of modulating the light emitted from the light source can be adopted without problems.

Further, it is also possible for the projector **100** to download the control program, which is stored in the storage section **180** in the embodiment described above, from another device connected via the communication network, and then execute the control program, or it is also possible to adopt the configuration of recording the control program on a portable recording medium, retrieving each of the programs from the recording medium, and then executing the program. The same can be applied to the display control program stored by the PC **300**, and it is also possible for the PC **300** to download the display control program from another device and then execute the program, or it is possible to adopt the configuration in which the PC **300** retrieves the display control program stored in a portable recording medium, and then executes the program.

The entire disclosure of Japanese Patent Application No. 2011-285318, filed Dec. 27, 2011 is expressly incorporated by reference herein.

What is claimed is:

1. A display device comprising:
- a function device connected to a host device and having a first interface and a second interface;
- a storage section storing configuration information, which assigns the same class to the first interface and the second interface;
- a display section adapted to display an image on a display surface;
- a detector adapted to discriminate between a first pointing body and a second pointing body for pointing to a position on the display surface, and detect a first position pointed to by the first pointing body and a second position pointed to by the second pointing body on the display surface; and
- a supply section adapted to assign first coordinate data representing the first position detected by the detector and supply the host device with the first coordinate data via the function device, and assign second coordinate data representing the second position detected by the detector and supply the host device with the second coordinate data via the function device,
- wherein the first pointing body and the second pointing body are external to the display device and the display surface.

2. The display device according to claim **1**, wherein
the storage section stores the configuration information, which assigns HID (Human Interface Device) class to the first interface and the second interface.

3. The display device according to claim **2**, wherein
the storage section stores the configuration information, which assigns a sub-class corresponding to a mouse to the first interface, and assigns a sub-class corresponding to a digitizer to the second interface.

4. The display device according to claim **2**, wherein
the storage section stores the configuration information, which assigns a sub-class corresponding to a mouse to the first interface and the second interface.

5. The display device according to claim **2**, wherein
the storage section stores the configuration information, which assigns a sub-class corresponding to a digitizer to the first interface and the second interface.

6. The display device according to claim **1**, wherein
the supply section supplies the host device with the configuration information stored in the storage section prior to supplying the host device with the first coordinate data and the second coordinate data.

7. The display device according to claim **1**, wherein
the display section displays the image on the display surface by projecting light.

8. The display device according to claim **7**, wherein
the storage section stores the configuration information, which assigns HID (Human Interface Device) class to the first interface and the second interface.

9. The display device according to claim **8**, wherein
the storage section stores the configuration information, which assigns a sub-class corresponding to a mouse to the first interface, and assigns a sub-class corresponding to a digitizer to the second interface.

10. The display device according to claim **8**, wherein
the storage section stores the configuration information, which assigns a sub-class corresponding to a mouse to the first interface and the second interface.

11. The display device according to claim **8**, wherein
the storage section stores the configuration information, which assigns a sub-class corresponding to a digitizer to the first interface and the second interface.

12. The display device according to claim **7**, wherein
the supply section supplies the host device with the configuration information stored in the storage section prior to supplying the host device with the first coordinate data and the second coordinate data.

13. The display device according to claim **1**, wherein
a sub-class corresponding to a mouse is assigned to the first interface and a sub-class corresponding to a digitizer is assigned to the second interface.

14. The display device according to claim **1**, wherein
a sub-class corresponding to a mouse is assigned to the first interface and the second interface.

15. The display device according to claim **1**, wherein
a sub-class corresponding to a digitizer is assigned to the first interface and the second interface.

16. A display system comprising:
a display device including
- a function device connected to an external device and having a first interface and a second interface,
- a storage section storing configuration information, which assigns the same class to the first interface and the second interface,

a display section adapted to display an image on a display surface,

a detector adapted to discriminate between a first pointing body and a second pointing body for pointing to a position on the display surface, and detect a first position pointed to by the first pointing body and a second position pointed to by the second pointing body on the display surface, and

a supply section adapted to assign first coordinate data representing the first position detected by the detector and supply the external device with the first coordinate data via the function device, and assign second coordinate data representing the second position detected by the detector and supply the external device with the second coordinate data via the function device; and

a host device connected to the display device in a manner compliant with the USB standard, and including

an execution section adapted to execute a process corresponding to one of the first position and the second position based on the first coordinate data and the second coordinate data supplied via the function device,

wherein the first pointing body and the second pointing body are external to the display device and the display surface.

17. The display system according to claim **16**, wherein

the execution section executes a process of making the display section draw an image corresponding to one of the first position and the second position.

18. The display system according to claim **16**, wherein

the supply section supplies the host device with the configuration information via the function device, and

the host device executes the process corresponding to one of the first position and the second position based on the configuration information, the first coordinate data, and the second coordinate data supplied via the function device.

19. A data supply method for a display device having a function device connected to a host device and having a first interface and a second interface, the method comprising:

displaying an image on a display surface;

discriminating between a first pointing body and a second pointing body for pointing to a position on the display surface;

detecting a first position pointed to by the first pointing body on the display surface;

detecting a second position pointed to by the second pointing body on the display surface;

assigning the same class to the first interface and the second interface;

assigning first coordinate data representing the first position detected in the detecting of the first position to the first interface and supplying the host device with the first coordinate data via the function device; and

assigning second coordinate data representing the second position detected in the detecting of the second position to the second interface and supplying the host device with the second coordinate data via the function device,

wherein the first pointing body and the second pointing body are external to the display device and the display surface.

20. The display device according to claim **1**, further comprising:

an imaging section adapted to capture an image of the display surface,

wherein, the detector discriminates between the first pointing body and the second pointing body based on the image captured by the imaging section and detects the first position and the second position based on the image captured by the imaging section.

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